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Use of Chlorofluorocarbon-Based Refrigerants in U.S. Army Facility Air-Conditioning and Refrigeration Systems

Recommendations for the Interim Period 1994-2000

by
Chang W. Sohn
Kelly O. Homan
Nancy Herring

Production of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) has been scheduled for phaseout because of the contribution of these chemicals to the depletion of the stratospheric ozone layer. CFC production is scheduled for phaseout by 1 January 1996; HCFC production will halt by the year 2020. The next generation of refrigerants is expected to be tested and widely available by the turn of the century. As a large-scale end user of CFC-based refrigerants, the U.S. Army is faced with a significant challenge by the phaseout of these chemicals.

This report makes recommendations for refrigerant use in U.S. Army facility air-conditioning and refrigeration applications for the interim period from the present to the year 2000. Only equipment using CFC refrigerants is addressed since the lifetime of equipment using HCFCs will expire before HCFC refrigerants are phased out. Available options to "run as-is," convert, or replace CFC-based machines should be examined in cooperation with reputable contractors representing the original equipment manufacturers (OEMs). Only refrigerants approved by the U.S. Environmental Protection Agency (USEPA) should be considered for use in retrofitted or replaced equipment. As a part of the equipment evaluation, opportunities to improve system efficiency and reliability should also be sought.

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Chang W. Sohn, Kelly O. Homan, and Nancy Herring

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This report makes recommendations for refrigerant use in U.S. Army facility air-conditioning and refrigeration applications for the interim period from the present to the year 2000. Only equipment using CFC refrigerants is addressed since the lifetime of equipment using HCFCs will expire before HCFC refrigerants are phased out. Available options to run as-is, convert, or replace CFC-based machines should be examined in cooperation with reputable contractors representing the original equipment manufacturers (OEMs). Only refrigerants approved by the U.S. Environmental Protection Agency (USEPA) should be considered for use in retrofitted or replaced equipment. As a part of the equipment evaluation, opportunities to improve system efficiency and reliability should also be sought.

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Foreword

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1 Introduction

Background

Scientific investigations of stratospheric ozone depletion in the early 1970s led to the identification of chlorofluorocarbons (CFCs) as a contributor to depletion of the stratospheric ozone layer. Studies showed that the CFC molecules are so stable that they survive unaltered until they reach the stratosphere. In the stratosphere, the chemical bonds of the CFC molecule are broken apart by the intense radiation; the chlorine atom(s) in the molecule begin a chain reaction resulting in the breakdown of large numbers of ozone molecules. This chain reaction produces an ozone destruction rate much greater than the natural ozone destruction rate (Rowland 1992). Reduction of the ozone layer allows increased levels of ultraviolet-B radiation to reach the earth's surface, affecting the environment and increasing levels of radiation that pose serious health risks to humans.

In response to data demonstrating depletion of the ozone layer and its link to CFCs and related substances, the United States and 22 other countries signed the Montreal Protocol in 1987. The protocol, which had been developed by the United Nations Environmental Program (UNEP), establishes phaseout schedules for the production and consumption of ozone-depleting substances (Figures 1 and 2). Additional scientific data demonstrating higher than anticipated levels of ozone depletion led to passage of Amendments to the Montreal Protocol, which accelerated the CFC phaseout and

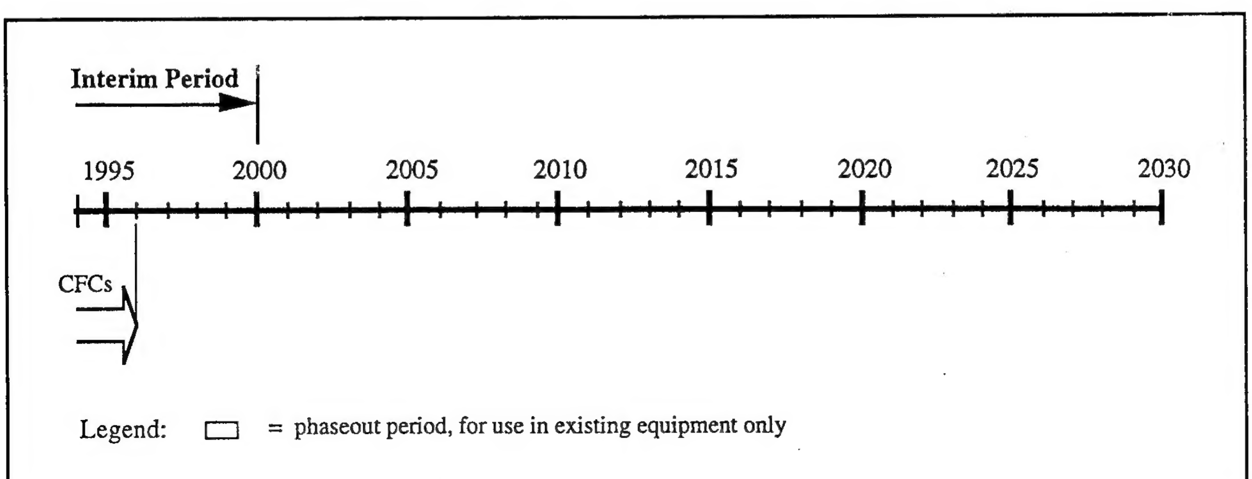

Figure 1. Phaseout schedule for CFC refrigerants.

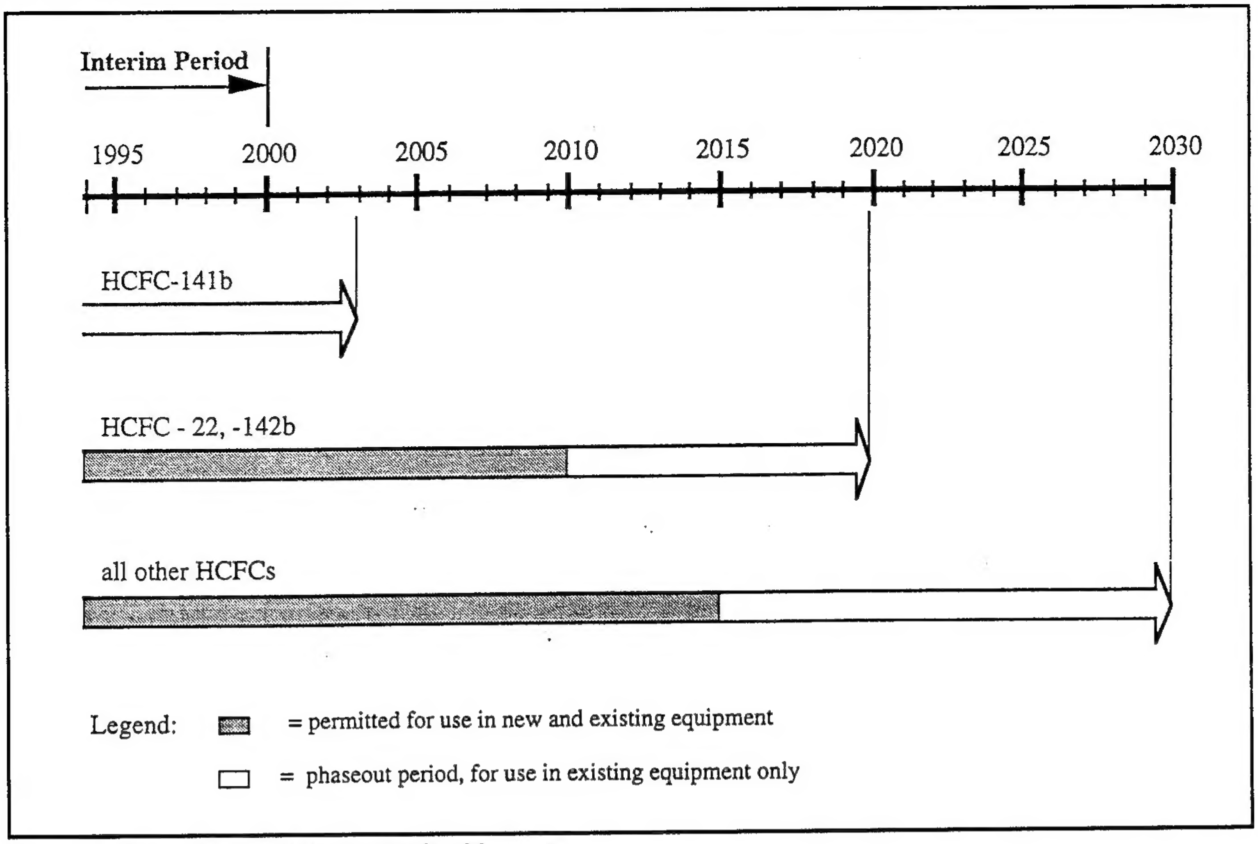

Figure 2. Phaseout schedule for HCFC refrigerants.

adoption of a phaseout schedule for substances including HCFC refrigerants (*International Legal Materials* 1990, 1992).

The rapid phaseout of CFC refrigerants called for in the Montreal Protocol has driven an intense search by the air-conditioning and refrigeration (AC/R) industry for alternative refrigerants. The scheduled phaseout of HCFC refrigerants further complicated matters for the AC/R industry. However, the phaseout schedule has been designed so that HCFC refrigerants can be used as transition refrigerants. These transition refrigerants are to remain in use while the next generation of environmentally friendly refrigerants is developed.

Large-scale end users of air-conditioning and refrigeration equipment especially need to anticipate the phaseout of CFC-based refrigerants and the accompanying change in cooling equipment specifications. As owner and maintainer of nearly 1 million tons of comfort cooling equipment and over 125,000 hp* of cold storage and refrigeration equipment, the U.S. Army is faced with a significant challenge by the phaseout of CFC-based refrigerants. This study outlines alternative strategies to help Army

* 1 ton = 12,000 Btu/hr; 1 hp = 745.7 Watts.

facilities make the transition to environmentally friendly refrigerants from the present until the year 2000.

Objective

The purpose of this study was to outline feasible alternatives for refrigerant use in Army facility air-conditioning and refrigeration equipment during the transition period from the present to the year 2000.

Approach

The regulatory requirements pertaining to Class I and Class II refrigerants were reviewed. Options for refrigerant use in Army facility air-conditioning and refrigeration equipment were reviewed and outlined. Recommendations were developed for each major type of equipment affected by the refrigerant phaseouts for the transition period extending from the present to the turn of the century, in which time the next generation of refrigerants will have been introduced.

Scope

This study addressed the use of refrigerants in Army facility air-conditioning and refrigeration equipment only. The use of these substances as solvents in manufacturing plants or as refrigerants in mobile air-conditioning systems was not considered. Recommendations were based on current legislative requirements implemented in response to ozone depletion concerns. Although global warming has received considerable attention in the news media, such concerns are not expected to significantly alter the choice of CFC alternative refrigerants during the refrigerant transition period. The Climate Change Action Plan issued by the Clinton Administration in 1993 affirmed the use of HFCs, in particular, for the transition away from CFC refrigerants (Miro and Cox 1994). The HCFC refrigerants recommended for use during the transition period have a lower Global Warming Potential (GWP) than the most common HFC refrigerants and are therefore even less likely to be affected by global warming concerns.

Mode of Technology Transfer

It is recommended that the information in this report be used to refine the Department of Defense/Department of the Army (DOD/DA) policy on CFC issues such as equipment phaseout schedules.

2 Regulatory Constraints

The Montreal Protocol of 1987 was the first international treaty to address the production and consumption of ozone-depleting substances. The Protocol divided ozone-depleting substances into two separate classes based on their Ozone Depletion Potential (ODP). Class I substances pose the most serious threat to the ozone layer and include the fully halogenated CFC refrigerants. Partially halogenated substances have been designated Class II substances and, although less hazardous to the ozone than Class I substances, still have a significant ODP. This chapter summarizes the regulatory constraints for Class I and II refrigerants.

Class I Refrigerants

Class I substances, which pose the most serious threat to the ozone layer, include the common CFC refrigerants. A production phaseout of these substances was part of the original Montreal Protocol in 1987. Two of the five groups included in the Class I designation include refrigerants. Table 1 lists the chemicals included in the two groups. Note that two of the most common refrigerants, CFC-11 and CFC-12, are included in the Class I designation. Two other refrigerants, refrigerant 500 and 502, are also affected by the phaseout because they are azeotropic blends that contain CFCs. Refrigerant-500 is a blend of CFC-12 and HFC-152a (73.8/26.2 percent by mass) and 502 is a blend of HCFC-22 and CFC-115 (48.8/51.2 percent by mass). The remaining three groups included in the original Class I designation are halons, carbon tetrachloride, and methyl chloroform.

In 1990, the parties to the Montreal Protocol met in London and adopted what came to be known as the London Amendments to the Montreal Protocol. The Amendments further accelerated the phaseout schedule of Class I substances in response to evidence presented in the 1988 Ozone Trends Panel Report that depletion of the stratospheric

Table 1. Refrigerants classified as Class I ozone-depleting substances.

Group	Description	Chemical Designation
I	Chlorofluorocarbons (CFCs)	11, 12, 113, 114, 115
III	Chlorofluorocarbons (CFCs)	13, 111, 112, 211, 212, 213, 214, 215, 216, 217

ozone layer was occurring more quickly than had been anticipated. The fourth meeting of the parties to the Protocol, in November 1992, produced the Copenhagen Revisions to the Montreal Protocol. Among other things, the complete production phaseout for Class I refrigerants was moved up to 1 January 1996 (Table 2).

In the United States, President Bush signed the Clean Air Act Amendments of 1990 into law on 15 November 1990 (3 years after the signing of the Montreal Protocol). Title VI of the Clean Air Act (CAA), "Stratospheric Ozone Protection," addresses issues related to protection of stratospheric ozone. The phaseout schedule for Class I substances was contained in Section 604 of Title IV in the CAA. The Clean Air Act Amendments included controls on the production and consumption of ozone-depleting substances that were, in some cases, more stringent than those contained in the 1990 London Amendments to the Montreal Protocol. Two years later, on 11 February 1992, President Bush unilaterally accelerated the production phaseout of all ozone-depleting (Class I) substances to the end of 1995. The presidential order was aggressive enough that U.S. policy was already in compliance with the phaseout schedule adopted later that year in the Copenhagen Revisions to the Montreal Protocol. The President's announcement was implemented with the Final Rule contained in Section 606 of the Clean Air Act Amendments. Table 1 and Figure 1 list the current phaseout schedule. Clearly, the deadline for the *production* phaseout is close at hand.

The phaseout does not, however, require an end to the *use* of CFC refrigerants. By law, service practices are now required to reduce the use and emission of refrigerants to the lowest achievable levels and to maximize recycling of the substances. This should ensure the availability of CFC refrigerants for a number of years.

Class II Refrigerants

The first international agreements addressing the production and consumption of Class II Ozone-Depleting Substances were the Copenhagen Revisions to the Montreal

Table 2. Class I refrigerant phaseout schedule, Section 606, Clean Air Act Amendments.

Year	Allowed percentage of CFC baseline production and consumption (Groups I & III)
1994	25
1995	25
1996	0

Protocol in 1992. Actions were taken to add HCFCs (Class II substances) to the list of chemicals to be controlled under the Montreal Protocol with a complete phaseout scheduled for the year 2030. Table 3 lists the included Class II substances. The most important refrigerants included in this class are HCFC-22, -123, and -141b.

As a result of President Bush's order for an accelerated phaseout of ozone-depleting substances in February 1992, the U.S. Environmental Protection Agency (USEPA) issued a phaseout schedule for HCFC refrigerants in Section 606 of the Clean Air Act Amendments. The overall schedule phases out specific refrigerants at different rates. The purpose was to allow a limited number of the HCFC refrigerants to be used as alternatives to Class I refrigerants while the next generation of refrigerants are in development. Table 4 and Figure 2 show the complete phaseout schedule. Note that the dates when HCFC-22 and HCFC-123 can no longer be used in *new* equipment are 2010 and 2015, respectively. These two HCFC refrigerants may continue to be produced for use in *existing* equipment until 2020 and 2030, respectively.

Table 3. Refrigerants classified as Class II ozone-depleting substances.

Description	Chemical Designation
Hydrochlorofluorocarbons (HCFCs)	21, 22, 31, 121, 122, 123, 124, 131, 132, 133, 141, 142, 221, 222, 223, 224, 225, 226, 231, 232, 233, 234, 235, 241, 242, 243, 244, 251, 252, 253, 261, 262, 271, and isomers

Table 4. Class II refrigerant phaseout schedule, Section 606, Clean Air Act Amendments.

Year	Substance	Restriction
2003	HCFC-141b	Ban on production and consumption
2010	HCFC-22, -142	Production and consumption frozen at baseline levels; production and consumption of these chemicals between 2010 and 2020 can only be used for the purpose of servicing equipment manufactured prior to 1 January 2010.
2015	All other HCFCs	Production and consumption frozen at baseline levels. Ban on use of virgin chemical unless used as feedstock or refrigerant in appliances manufactured prior to 1 January 2020.
2020	HCFC-22, -142b	Complete phaseout
2030	All other HCFCs	Complete phaseout

3 Suggested Measures

The CFC and HCFC refrigerant phaseout schedules impact not only the AC/R equipment manufacturers but also AC/R equipment users. The U.S. Army owns and maintains nearly 1 million tons of comfort cooling equipment and over 125,000 hp of cold storage and refrigeration equipment. The refrigerant phaseout presents a significant challenge for the Army. A recent USACERL study (Sohn, Homan, and Sliwinski 1992) found the U.S. Army facility air-conditioning and refrigeration inventory includes approximately 2.5 million lb of refrigerants, of which 1.39 million lb (55.4 percent) are CFC-based refrigerants (1 lb = 0.454 kg). Fortunately, the CFC refrigerants are being used in fairly specific types of equipment: large chillers (air-conditioning loads of over 100 tons) and refrigeration/cold storage equipment. The remainder of the equipment serves smaller air-conditioning loads and generally uses HCFC-22 as the refrigerant. This natural breakdown of types of equipment by use provides the structure for the remaining sections of this chapter.

Dealing with existing CFC equipment comes down to three basic options. The equipment can be (1) "run as-is" making sure emission rates are within regulatory limits, (2) converted to the use of alternative refrigerants, or (3) simply replaced with new units designed for use with alternative refrigerants. In all cases, the overall goal of every equipment management program should be refrigerant conservation (Ostman 1993). CFC refrigerants will become increasingly expensive and alternative refrigerants are expected to remain expensive for some time; therefore, it is important to preserve the refrigerant being used in all types of AC/R equipment. This can be accomplished with periodic leak testing and repair to minimize refrigerant loss, the addition of high efficiency purge units (for low pressure systems), proper handling of recovered and recycled refrigerants, and adequate training for personnel. To assist in this area, USACERL has gathered a thorough listing of manufacturers and vendors of refrigerant leak-detecting equipment to be published at a later date in a USACERL Technical Report (Sohn 1994a). For compliance with the recordkeeping requirements of the Clean Air Act Amendments and to aid the management of a refrigerant inventory, USACERL has also developed a PC-based refrigerant management program that can be used to track refrigerant transactions associated with the operation and maintenance of AC/R systems.

Fortunately, the U.S. government is providing some assistance in sorting through the maze of refrigerant options. Section 612 under Title VI of the Clean Air Act Amendments authorizes the EPA to identify and restrict the use of substitutes for Class I and Class II ozone-depleting substances. The USEPA is referring to this program as the Significant New Alternatives Policy (SNAP). A key goal of SNAP is to promote the use of alternatives to Class I and Class II substances that minimize human health risks and are environmentally friendly. The USEPA published a Final Rule (FR) on 18 Mar 1994 (Federal Register, Vol 59, p 13044) that contains preliminary decisions on the acceptability of certain substitutes and introduces its plan for administering the SNAP program. A final ruling is expected in Spring 1994. The restrictions put forward in the proposed SNAP program have been included in the recommendations in this report.

Large AC Units (Water Chillers)

Traditionally, water chillers of over 100 tons capacity have been designed with centrifugal compressors and CFC refrigerants. The most commonly used refrigerants for this group of equipment were CFC-11, CFC-12, CFC-500, and HCFC-22. Existing chillers using HCFC-22 require no immediate attention other than prevention of unnecessary refrigerant release per EPA rules. It is likely these machines will have reached the end of their useful lifetime before the phaseout of this refrigerant. The machines of interest in this section are therefore those using the CFC refrigerants.

Maintain/run as-is

One option for dealing with existing CFC equipment, which should not be overlooked, is to leave it running as-is. This option is probably most appropriate for older chillers in good operating condition. Keeping this equipment in operation for even a few years will allow time for the market to clear up and, quite possibly, for new equipment prices to decline. Replacement CFC refrigerants will continue to be available as recycling and reclamation programs develop, although the cost will surely continue to rise. Thus, the success of this option will depend on management and service practices that minimize the need for purchasing replacement refrigerant. An important advantage to maintaining some of the equipment in its current configuration is that maintenance personnel are already familiar with the operation and maintenance procedures. This could help prevent maintenance personnel from being overloaded with new operation and maintenance procedures during this transition period.

Retrofit/conversion

The second available option is to convert CFC-based machines to an alternative refrigerant. Generally, this option will be economical for newer machines (those less than 5 years old). Even for these newer machines, the decision to convert to an alternative refrigerant should be considered very carefully. The decision should be based on a life-cycle cost analysis that includes such factors as: remaining life of the chiller, first cost of conversion, energy costs (conversions may change energy consumption rates), loss of capacity, and operation and maintenance costs. The remaining life must be factored into the decision since a conversion will probably not increase the useful life of the machine. A reliable contractor should be able to provide a feasibility study as a prerequisite to performing the actual conversion. As part of the feasibility study, the contractor should be able to provide estimates of efficiency, capacity loss, expected lifetime, etc. Contractors who can perform both the feasibility study and the actual conversion as well as having strong ties to the original equipment manufacturer (OEM) should be sought. Strong ties to the OEM are so crucial because the alternative refrigerants have different chemical compositions and often use different lubricants than those specified in the original system design. The OEM is in a better position to know which seals, gaskets, and other parts must be replaced to achieve a successful conversion. This is especially important because material incompatibility problems that may not surface immediately could eventually lead to catastrophic failures.

For low pressure systems, CFC-11 has been the most commonly used refrigerant. As an alternative to CFC-11, HCFC-123 is not a drop-in substitute. Although the same oil as used in CFC-11 systems can be used in the R-123 systems, HCFC-123 is a more aggressive solvent. Depending on the construction of the particular chiller, conversion to HCFC-123 may require that seals, gaskets, bushings, diaphragms, motor insulation, or even the compressor motor be replaced. A retrofit addressing only the material compatibility requirements would likely result in efficiency losses of up to 5 percent and capacity reductions of up to 20 percent (Calm 1992). The reductions in capacity and efficiency are due, in part, to a higher specific volume (m^3/kg) of HCFC-123 vapor and lower speed of sound (m/s). Correcting this with modifications to the compressor and refrigerant flow metering devices, the decrease in efficiency would be between 2 and 4 percent with a loss in capacity of less than 5 percent (Calm 1992; Smithart 1993). The cost for this type of conversion on a hermetic chiller should run about 20 to 40 percent ($60 to $140 per ton) of the cost of a replacement chiller (Smithart 1993).

For high pressure systems using CFC-12 and CFC-500, the primary substitute is HFC-134a. HFC-134a has shown excellent material compatibility with polymers and metals used in centrifugal chillers (Clark et al. 1991). However, the mineral oils typically

used with CFC-12 are insoluble in HFC-134a. The HFC-134a systems must use synthetic oils. A direct conversion from CFC-12 or R-500 to HFC-134a that includes the new refrigerant and service time to flush the system of its mineral oil and recharge with the recommended synthetic oil will cost approximately 26 percent of a new chiller price (Parsnow 1993). The conversion from CFC-12 will result in an 8 to 10 percent capacity loss with a 1 to 2 percent loss in efficiency. Conversions of R-500 chillers result in little or no capacity loss and about 0.5 percent efficiency loss (Parsnow 1993). As with the low pressure systems, a more extensive retrofit can regain the capacity and efficiency of the original configuration. This would require changes in impeller size and/or speed (Calm 1993).

Under authority of Section 612 of the CAA, as amended in 1990, the USEPA has developed the SNAP program for identifying substitutes to the refrigerants being phased out. Approval by the USEPA under SNAP must be a precondition for consideration of any alternative refrigerant. Table 5 lists the refrigerant alternatives reviewed by the USEPA for use in retrofitting chillers. Alternative refrigerants approved by the USEPA and familiar to the OEM should be considered as the only viable options for a conversion.

Replacement

The final option for compliance is replacement of existing machines with new equipment. This option should be reserved for machines in poor condition that are not cost-effective to fully repair. Table 6 lists the USEPA-approved alternatives for new chillers. Even though HCFC refrigerants are scheduled for phaseout, it is perfectly acceptable to purchase new equipment that uses approved HCFC refrigerants during the period up to the year 2000. The useful lifetime of this equipment will likely not extend beyond the phaseout of refrigerant production. As with CFC refrigerants, HCFC refrigerant will continue to be available after production has been phased out.

Table 5. Alternative refrigerants reviewed by the USEPA for retrofitting chillers.

	Chemical			
Application	HCFC-123	HFC-134a	HCFC-22/HFC-152a/HCFC-124	HCFC-22/HCFC-142b/CFC-12
CFC-11 centrifugal chillers	A			
CFC-12 centrifugal chillers		A		U
CFC-500 centrifugal chillers		A	A	U
CFC-12 reciprocating chillers		A		U
Legend: A = Acceptable; U = Unacceptable				

Table 6. Alternative refrigerants reviewed by the USEPA for new chillers.

	Chemical									
Application	HCFC-123	HCFC-22	HFC-134a	Ammonia	Lithium-Bromide Water Absorption	Ammonia-Water Absorption	HCFC-141b	HCFC-22/HCFC-142b/CFC-12	HFC-227a	HCFC-142b
CFC -11 centrifugal chiller	A	A	A	A	A	A	U			
CFC-12 centrifugal chiller	A	A	A	A	A	A		U	P	
CFC-500 centrifugal chiller	A	A	A	A	A			U		
CFC-12 reciprocating chiller		A	A					U		P

Legend: A = Acceptable; U = Unacceptable; P = Pending

Small to Mid-Sized Equipment

These machines serve air-conditioning loads of less than 100 tons and are generally based on reciprocating compressors using HCFC-22. Examples of this type of equipment are window air-conditioners, family housing split units, and small building air-conditioning units. Since this equipment uses HCFC-22 almost exclusively, there is no need for conversion. Units should only be replaced at the end of their useful lifetime. Replacement with identical units (HCFC-22) is probably the best choice during the interim period. Hopefully, systems using the next generation of refrigerants will appear by the turn of the century.

Cold Storage and Refrigeration

The cold storage and refrigeration equipment is the remaining group using large amounts of CFC refrigerants. A total capacity of over 126,000 hp of equipment in the U.S. Army is estimated to be using nearly 700,000 lb of CFC-12 and R-502 refrigerants (Sohn, Homan, and Sliwinski 1992). This segment of the CFC-based equipment inventory is especially important because the systems are normally custom-designed

and field-assembled. This increases the likelihood of refrigerant leaks developing in the system as compared to OEM-designed and manufactured package units. Examples of this group of equipment are systems used for retail food refrigeration and warehouse food storage. These systems are usually designed around reciprocating compressors. The larger systems (compressors larger than 5 hp) generally use CFC-12 as the refrigerant. Smaller systems are designed for use with CFC-12, R-502, or HCFC-22, depending upon the application.

An important exception to the recommendations for this group are the small, self-contained refrigeration systems such as refrigerators, reach-in coolers, beverage coolers, etc. These systems typically contain only a small amount of refrigerant and develop leaks only under rare circumstances. Even though they may be using CFC refrigerants, these systems should only be replaced with non-CFC systems when there has been a system failure and repair is not economical.

As with air-conditioning, equipment using HCFC-22 should be maintained as-is. The only exception should be systems that, because of age or design, are leaking excessively and cannot be repaired economically. As discussed earlier, HCFC-22 has been approved by the USEPA for use during the interim period and will continue to be available for quite some time.

Selecting CFC equipment to be run as-is should be done very carefully. Systems in good operating condition that would be prohibitively expensive to convert would probably be the best candidates. Putting off the transition to alternative refrigerants for these systems allows available funds to be invested in more needed equipment conversions and replacement and may also provide future benefits in terms of reduced new equipment prices and availability of next generation refrigerants.

Some refrigeration equipment is being retrofitted. The most common conversion is from CFC-12 to HFC-134a. Although successful conversions have been reported in the private sector (Corr et al. 1993), this option should be considered with the same caution as the retrofit of chiller systems. Conversions should only be done by contractors who are able to demonstrate the economic feasibility of the conversion and have strong ties to the original equipment manufacturer. The best candidates for conversion will probably be newer systems that are in good operating condition. Equipment modifications necessary for a R-134a system to equal or better the capacity of the existing R-12 system include: (1) replacement or adjustment of the expansion device, (2) use of a R-134a compatible dessicant (filler/drier), and (3) replacement of incompatible materials. Especially important is to flush the old oil from the system and replace it with an R-134a-compatible oil. Generally, medium to high temperature (above zero degrees Celsius) R-12 systems have been converted since changing the

compressor displacement is not necessary (Corr et al. 1993). Table 7 lists the refrigerants approved by the USEPA for use in retrofitting CFC-12 and R-502 systems.

The remaining option is to replace old units with new equipment. This requires the largest initial investment. The best candidates are systems in poor condition and that cannot cost-effectively be put in good condition. Table 8 lists the alternative refrigerants approved by the USEPA for new equipment.

Table 7. Alternative refrigerants reviewed by the USEPA for retrofitting refrigeration systems.

	Chemical				
Application	HCFC-22	HFC-134a	HCFC-22/HFC-152a/HCFC-124	HCFC-22/Propane/HFC-125	HCFC-22/HCFC-142b/CFC-12
CFC-12 cold storage warehouse systems	A	A	A		U
CFC-12 retail food refrigeration systems	A	A	A		U
R-502 cold storage warehouse systems	A			A	
R-502 retail food refrigeration systems	A			A	

Table 8. Alternative refrigerants reviewed by the USEPA for new refrigeration systems.

Application	Chemical									
	Ammonia	HCFC-22	HFC-134a	HCFC-22/Propane/HFC-125	HCFC-22/HCFC-142b/CFC-12	Hydrocarbon Blend A	HFC-227ea	HFC-125	HFC-125/HFC-143a/HFC134a	R-200a
CFC-12 cold storageware house system	A	A	A		U	U	P			
CFC-12 retail food refrigeration system	A	A	A			U	P			
R-502 cold storage warehouse system	A	A		A				P	P	P
R-502 retail food refrigeration system	A	A		A				P	P	P
Legend: A = Acceptable; U = Unacceptable; P = Pending										

4 Conclusions and Recommendations

As a large-scale owner and maintainer of cooling and refrigerating equipment, the U.S. Army is affected by the phaseout of CFC-based refrigerants. This study has outlined the following strategies to help the Army make the transition to more environmentally friendly refrigerants in a timely and economical manner.

Large Air-Conditioning Units

The option to maintain large air-conditioning units (water chillers) in as-is operating condition must not be overlooked. It is anticipated that recycling and reclamation programs will allow CFC refrigerants to remain available for some time after their production has halted. As an interim measure, keeping well-maintained and serviced units in operation can allow time for the commercial market to adjust to production and demand for new air-conditioning products and for prices to decline.

Retrofit of large air-conditioning units to alternative refrigerants may be a feasible option for newer machines where a cost benefit can be achieved. This decision should be based on an appropriate life-cycle analysis that includes (minimally): (1) remaining life of the chiller, (2) conversion first cost, (3) energy costs, (4) loss of capacity, and (5) operation and maintenance costs.

For older systems that are not cost-effective to repair, replacement may be the most feasible option. During the transition period, purchase of equipment designed for HCFC refrigerants is still an acceptable alternative, considering the lifespan of the equipment will likely not extend beyond the phaseout of the refrigerant.

Small to Mid-Sized Equipment

Equipment serving air-conditioning loads less than 100 tons should not require conversion. Units of this type should simply be replaced after their useful lifetime. Again, during the interim period, replacement with equipment that uses HCFC-22 is an acceptable option.

Cold Storage and Refrigeration Equipment

The option to maintain cold storage and refrigeration equipment as-is should be exercised with care. Note that the same considerations apply to these units as apply to the (previously discussed) chiller.

Small, self-contained refrigeration systems, e.g., refrigerators or beverage coolers, contain only small amounts of refrigerant and rarely develop leaks. Such equipment may be maintained until there is a system failure and repair is not economical. Delaying the change to non-CFC refrigerants in these less critical systems can free funds for more needed equipment conversions and replacement.

General Guidelines

In all cases, some general principles come to bear:

- The transition to new refrigerants will be rapid. The next generation of refrigerants are expected to be widely available shortly after the turn of the century.

- In both new and converted equipment, it is vital to use only refrigerants approved by the USEPA under the SNAP program. Specific HCFC refrigerants have been approved for use during the transition period.

- The "run as-is" option should be taken only for CFC equipment in good operating condition. Good management and service practices are important to conserve the CFC refrigerant presently in use. In a few years, the equipment should be replaced with next generation equipment.

- Retrofit of newer CFC equipment should be made only to alternative refrigerants approved by the USEPA under SNAP. Contractors to perform equipment retrofit should demonstrate an ability to provide a thorough feasibility study and should have close ties to the original equipment manufacturer.

- Consider for replacement only equipment that cannot be brought into compliance economically.

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